Table 11.3. (continued)

Lat Lon	Local 1 hr, 10 mi²	General 1 hr, 10 mi²	General/Local 1-hr ratio	Local 6 hr, 10 mi²	General 6 hr, 10 mi²	General/Local 6-hr ratio
37° -121°	4.41	1.71	0.39	5.73	5.51	0.96
37° -120°	4.32	1.18	0.27	5.62	3.82	0.68
37° -119°	6.21	3.13	0.50	8.07	9.40	1.16
37° -118°	7.92	1.30	0.16	9.90	3.89	0.39
36° -121°	4.86	1.76	0.36	6.32	6.08	0.96
36° -120°	4.32	1.39	0.32	5.62	4.48	0.80
36° -119°	4.46	1.32	0.30	5.80	4.26	0.73
36° -118°	7.43	1.72	0.23	9.66	5.17	0.54
36° -117°	8.73	3.76	0.43	11.35	7.51	0.66
36° -116°	9.45	2.96	0.31	11.81	5.93	0.50
35° -120°	5.36	3.82	0.71	6.97	13.09	1.88
35° -119°	6.03	1.09	0.18	7.84	3.52	0.45
35° -118°	8.15	2.38	0.29	10.60	4.76	0.45
35° -117°	9.09	2.65	0.29	11.82	5.30	0.45
35° -116°	9.54	2.71	0.28	12.40	5.42	0.44
35° -115°	9.90	4.41	0.45	12.87	8.81	0.68
34° -118°	6.75	2.77	0.41	9.45	9.48	1.00
34° -117°	10.22	2.69	0.26	14.31	9.23	0.65
34° -116°	10.40	3.76	0.36	14.56	7.51	0.52
34° -115°	10.22	3.88	0.38	13.29	7.76	0.58
33° -117°	8.10	1.87	0.23	11.34	6.40	0.56
33° -116°	10.85	3.76	0.35	15.19	7.52	0.50
33° -115°	10.56	4.01	0.38	13.73	8.03	0.58

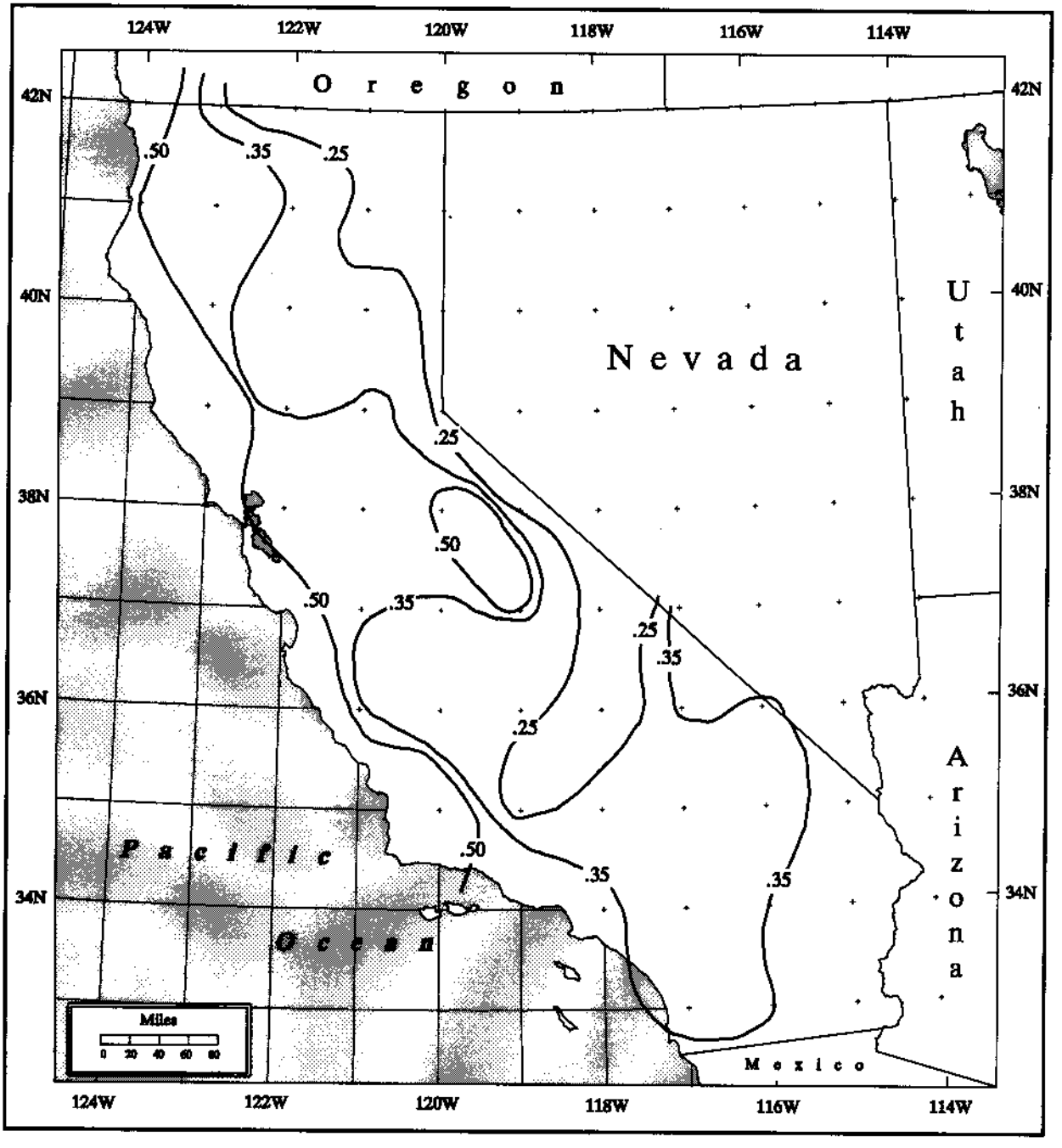

Figure 11.5. *Ratios of general-storm to local-storm PMP estimates at 1 hour, 10 mi².*

coast where local-storm values are at their lowest and general-storm values are relatively high. At 6 hours, 10 mi^2 the differences between general-storm and local-storm PMP become larger, as seen in Figure 11.6. Along the coast general-storm to local-storm ratios are well over one, but quickly fall off inland. Again a secondary maximum (> 1.0) occurs along the Sierra Nevada mountains. The maximum ratio values stretch along the northwestern coast of California and reach a high of 2.13.

These comparisons are somewhat forced or artificial in that for all but the southeastern region, (Chapter 3, Figure 3.2), the general-storm values are usually from wintertime storms, whereas local-storm values come from summertime events. Had the comparisons been made during the summertime months alone, one could expect the ratios shown in Figure 11.5 and 11.6 to be somewhat lower. Both figures demonstrate the need to examine both types of storms when trying to determine PMP for a specific location. These figures show a small sample of the range of possible PMP comparisons.

11.5 Comparison to Adjoining PMP Studies

The California study region is surrounded by the Pacific Ocean, Oregon, Nevada, Arizona, and Mexico. HMR 57 for Oregon and Washington borders the region on the north and HMR 49 not only borders on the east but applies to the areas east of the Sierra Nevada mountains and the desert southeast. This section will examine how the results of the new PMP agree with these two studies.

11.5.1 Comparison to HMR 57

Although this report was developed independently of neighboring studies, many of the same techniques were applied from earlier hydrometeorological reports to prepare HMR 59. HMR 57 borders HMR 59 on the north along 42°N and storms that have centers in northern California were also used for PMP calculations in Oregon and Washington. Likewise, storms used in HMR 57 were used in California. Thus, the two studies used some of the same data. In addition, the means of analysis and methodology were similar, allowing a certain level of continuity.

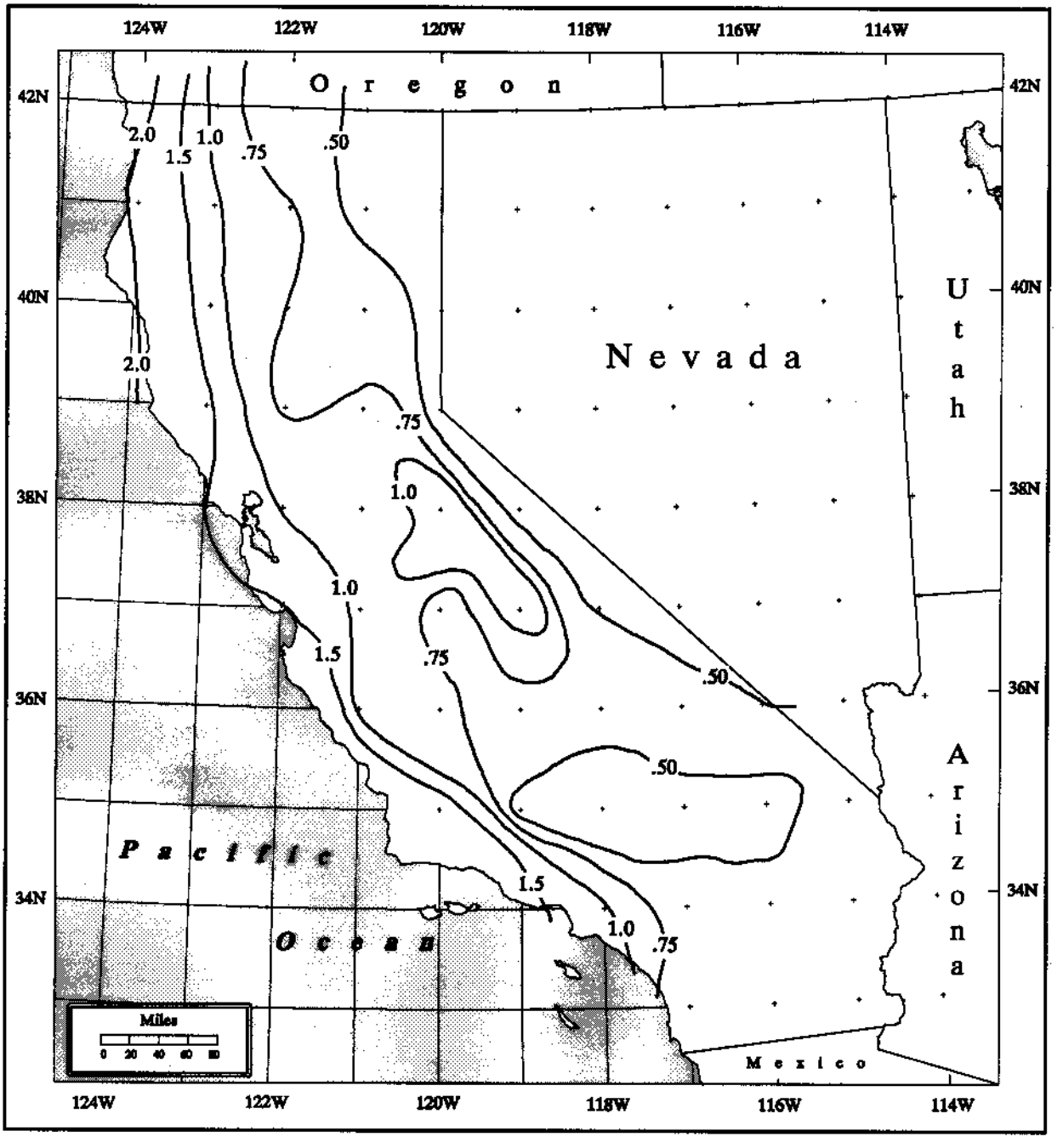

Figure 11.6. *Ratios of general-storm to local-storm PMP estimates at 6 hours, 10 mi².*

The 24-hour, 10-mi^2 PMP Index analysis from HMR 59, with a few minor adjustments, agrees with HMR 57 rather closely. This is to be expected since HMR 57 was recently completed (as far as HMRs are concerned) and the methods used were very similar to those used for this study. At all area sizes and durations, the differences are minor due to the similarity of methodology and data. Table 11.4 shows the relative differences in percent between the HMR 59 and HMR 57 depth-area-duration relations. The greatest differences appear at area sizes of 500 mi^2 and less. Negative differences (HMR 59 less than HMR 57) up to 8.7 percent, at 6 hours, 100 mi^2 are noted. At area sizes of 2000 to 5000 mi^2 and durations equal or greater than 24 hours, the relations actually reverse slightly so that by 48 hours, 5000 mi^2, HMR 59 values are one percent higher than HMR 57. In all other cases, the values in HMR 59 are zero or slightly less than HMR 57 along the border between Oregon and California.

Table 11.4. *Percent differences in depth-area factors at 42° N (HMR 59 minus HMR 57).*

mi^2	1 hr	6 hr	24 hr	48 hr	72 hr
10	0.0	0.0	0.0	0.0	0.0
50	-7.0	-7.7	-6.1	-4.75	-3.8
100	-7.0	-8.7	-5.7	-5.2	-3.8
200	-6.5	-8.0	-5.9	-4.8	-3.15
500	-3.1	-5.7	-3.95	-2.6	-1.3
1000	-2.2	-3.8	-1.7	-0.5	+0.3
2000	-0.4	-1.3	+0.1	-0.2	0.0
5000	-0.3	-0.3	+0.8	+1.0	+0.2
10000	-0.2	-0.3	-0.2	0.0	0.0

11.5.2 Comparison to HMR 49

HMR 49 covers the Colorado and Great Basin drainage that includes a large portion of eastern California. More specifically, HMR 49 includes areas just east of the Sierra Nevada mountains and the deserts of southeast California. Comparisons were conducted throughout the region for various area sizes and durations where HMR 59 and HMR 49 overlap and are shown in Table 11.5. The depth-area-duration (DAD) regions from HMR

59 (Chapter 3, Figure 3.2) that are also covered in HMR 49 include the Northeast, Sierra, Southeast, and Southwest.

Table 11.5. *Average percentages of HMR 59 Index values compared to HMR 49. The Northeast region consists of 5 data points, the Sierra has 6 data points, and the Southeast has 33 data points.*

Region	mi^2	6 hr	12 hr	24 hr	48 hr	72 hr
Northeast	10	125	114	118	119	113
	200	125	111	112	114	109
	1000	132	111	110	112	107
	5000	127	98	96	96	93
Sierra	10	84	87	93	105	103
	200	81	83	88	100	100
	1000	82	82	86	98	100
	5000	81	79	82	93	96
Southeast	10	88	95	89	85	87
	200	89	96	89	85	88
	1000	88	94	87	82	85
	5000	79	85	77	71	73

As for methodology, HMR 49 was not based exclusively upon storm-derived DAD as were HMR 57 and HMR 59 . Therefore, agreement between HMR 59 and HMR 49 PMP values were not expected to be as close as those found between HMR 59 and 57. Another difference is that HMR 49 does not permit 1-hour general-storm PMP estimates to be determined directly so comparisons cannot be made at this duration. Furthermore, the relationship between HMR 59 and HMR 49 differs markedly from the variation reported between HMR 59 and HMR 36. As noted above, HMR 59 PMP is larger than HMR 36 at small-area sizes. However, differences decrease as area sizes increase. Differences between HMR 59 and HMR 49 are not nearly as consistent. In general, HMR 59 PMP values, at all area sizes from north to south, transition from greater than HMR 49 PMP values in the north to less in the south. Within the regions themselves the most prevalent tendency is for HMR 59 values to decrease with respect to area size.

For the three regions adjacent to HMR 49 composite averages were made using data points from each area. Clearly, in the Northeast region, HMR 59 values are larger at most durations and area sizes (Table 11.5). The largest positive differences occur at 10 mi^2 and slowly decrease with increasing area size and to some extent with duration. At 5000 mi^2, however, HMR 59 values become slightly less than HMR 49.

In the Sierra region, along the east side of the Sierra Nevada mountains HMR 59 PMP values, for the most part, fall below HMR 49 levels. However, PMP values in HMR 59 are nearly equal to or larger than HMR 49 at 48 and 72 hours for all of the Sierra regions. HMR 49 is greater at all 6-hour and 12-hour areas and nearly equal otherwise.

In the Southeast region, HMR 59 PMP values are less than HMR 49 PMP values. These differences tend to increase with increasing area size (i.e., ratios are smaller) and to a lesser extent with duration. Most comparisons in this region show that changes are less than 25 percent except in a few areas along the region boundaries where some larger variations do exist due to the classification of regions.

12. CONCLUSIONS AND RECOMMENDATIONS

This report, HMR 59, presents principles and development of probable maximum precipitation (PMP) for California. It is a revision of HMR 36 (1961) and the California area of HMR 49 (1977). The methodology is much the same as in HMR 55A (Colorado River Basin, 1988) and HMR 57 (northwestern United States, 1994). PMP estimates from this study are compared with its predecessors, HMR 36 (California) and HMR 49 (Colorado River and Great Basin Drainages), and with other indices, such as record storms in other parts of the world in order to evaluate the results. HMR 59 includes all of the procedures for calculating PMP and describes the principles and development of PMP estimates for 10 mi^2 to 10,000 mi^2 and 1 to 72 hours. Local-storm PMP estimates are described for 1 mi^2 to 500 mi^2 and 15 minutes to 6 hours. HMR 58 (1998), its immediate predecessor contains, in entirety, the PMP calculation procedures, including snowmelt, which are found here in Chapter 13 and Appendix 4. HMR 58 and HMR 59 are different presentations of the same study, with HMR 58 containing calculation procedures only, and HMR 59 containing a description of the complete study, including the calculation procedures.

Among the important achievements and conclusions set by this study are:

1. HMR 58 (1998), Calculation Procedures for California PMP is the first Hydrometeorological Report available in full on the world wide web. HMR 58 is a section of HMR 59.

2. Established a digital storm analysis procedure to routinely analyze major storms in an objective, consistent, and timely manner. A geographic information system (GIS) was employed to develop spatial and temporal relationships important for depth-area-duration (DAD) analysis and finally for PMP estimate calculations.

3. All-season, general-storm PMP estimates and monthly variations are provided for area sizes of 10 to 10,000 mi^2 and durations up to 72 hours. Besides the all-season general-storm PMP Index values, seasonal adjustments were prepared for all months of the year.

4. New climatologies of 3-hour and 12-hour maximum persisting dewpoints were developed.

5. PMP for California was established that is consistent with PMP for the Pacific Northwest (HMR 57).

6. In comparison with HMR 36 Index values Index PMP (10-mi^2, 24-hour) has increased substantially in certain sections of the Coastal Mountains, and along the length of exposed portions of the Sierra Nevada; and decreased in limited areas in non-orographic regions and locations downwind of significant mountains.

7. Short-duration, general-storm PMP values (1, 6, 12 hours) are higher than HMR 36; while longer-duration (24, 48, 72 hours) values have remained constant or decreased for the most part.

8. As a function of area size, general-storm PMP values have increased substantially for drainages smaller than 200 mi^2, while for areas greater than 200 mi^2 PMP values are generally less than in HMR 36.

9. The ratios between PMP values at 24 hours and 100-year precipitation values from NOAA Atlas 2 were found to be consistent with similar comparisons made in other parts of the western United States.

10. Local-storm PMP estimates were provided for all of California, including the northwest corner of the state which had not been covered by HMR 49.

11. A synoptic climatology for local storms was developed and was used to set 6-hour to 1-hour ratios of point rainfall for California local storms.

12. Local-storm PMP values are about 10 to 15 percent higher in California north of 40°, compared with HMR 49; while changes over most of the rest of the state were plus or minus 5 percent. Durationally, little change was found at 1 hour, but a wider range of decrease was found at 6 hours.

13. The PMP estimates derived for this report are the best available for California, and should be applied to all future design studies.

14. The estimates available from this report represent storm-centered, average depths of PMP that form the basis for site-specific applications.

15. The procedures provided in Chapter 13 are relatively simple to apply, and cover both general-storm and local-storm PMP applications.

As a consequence of this study, the following recommendations are made:

1. That future effort be made to determine how best to areally and chronologically distribute average PMP values from this study.

2. That climatological data be reviewed to determine whether the recommended time sequences of temperature, dewpoints, winds and precipitation used in Appendix 4 (Snowmelt) continue to be appropriate; that future study on the probable maximum snowpack and corresponding maximum rainfall be done.

3. Although storm analysis was accomplished relatively quickly, work towards a more automated system should be continued. This will enhance the ability to archive more storm events as they happen.

4. That effort be made towards applying radar precipitation data to current and future analysis, both storm spatial and durational. A bridge towards radar data and away from the Theissen polygon approach would be a positive step. Since much of the country is covered by WSR-88D radar, and data collection procedures are in place, data transfer to a GIS system is possible.

5. Work with model developments to enhance the understanding of physical processes assumed in this and other PMP studies.

6. That studies be carried out for California considering basin and storm area sizes, seasonality at the geographic variation of antecedent precipitation.

13. COMPUTATIONAL PROCEDURE

13.1 Introduction

The steps to calculate probable maximum precipitation (PMP) for general and local storms in California are provided in this chapter. All tables, figures, and plates are included here. As in the procedures recommended in HMR 55A (1988) and HMR 57 (1994), these steps produce storm-centered, average depths of PMP applicable to a specific drainage.

General-storm PMP may be determined for durations from 1 to 72 hours over areas from 10 to 10,000 mi^2, and local-storm PMP may be determined for durations from 15 minutes to 6 hours over areas between 1 and 500 mi^2. When making PMP estimates for basins less than 500 mi^2, it is recommended that both general and local-storm PMP be calculated. The larger of these estimates represents the basin PMP. The decision as to which of these results is most critical for the basin involves hydrological considerations related to flooding, and are beyond the scope of this report. The final selection of PMP, local- or general-storm value, is a choice for the user. Seasonal variation of general-storm PMP has been included to aid the user when other hydrologic factors have a bearing on water management decisions. The seasonal information is shown in Figures 13.1 to 13.10.

We have attempted to keep the computational procedure in this report simple and straightforward. The Index PMP map was drawn for the general storm at 1:1,000,000 scale for northern and southern sections of California, with an overlap of at least one degree of latitude. The maps contain latitude and longitude markings, county boundaries, and selected cities or towns. In addition, each index map contains regional boundaries for use with DAD relations. These maps accompany this report, Plates 1 and 2. See Endnote[1] for map supplement requests.

If calculations are being made for a drainage which encompasses more than one DAD region (Figure 13.11, and also outlined on Plates 1 and 2), use proportionally-weighted

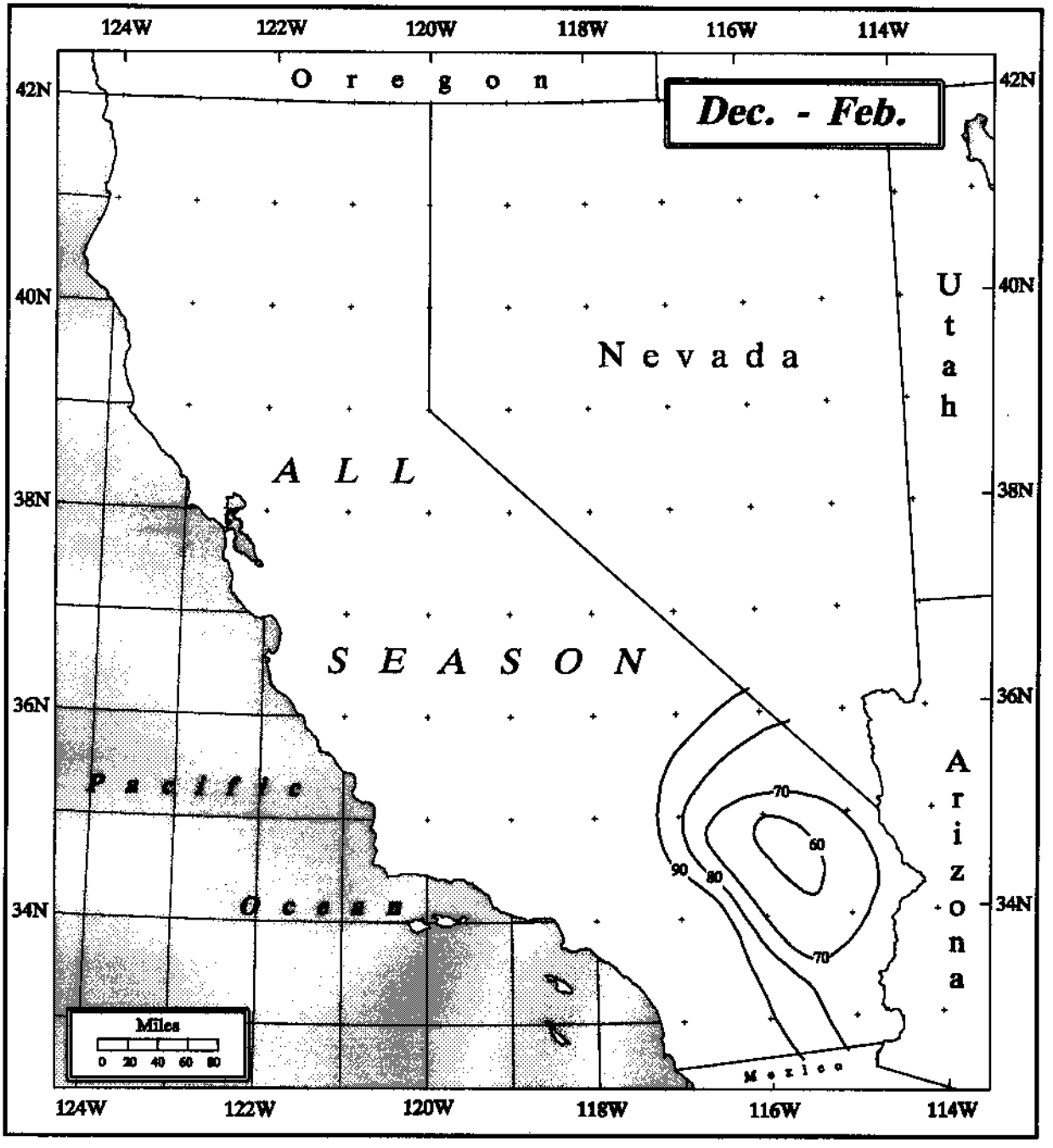

Figure 13.1. *10-mi² 24-hour general-storm PMP for December through February in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.2.*

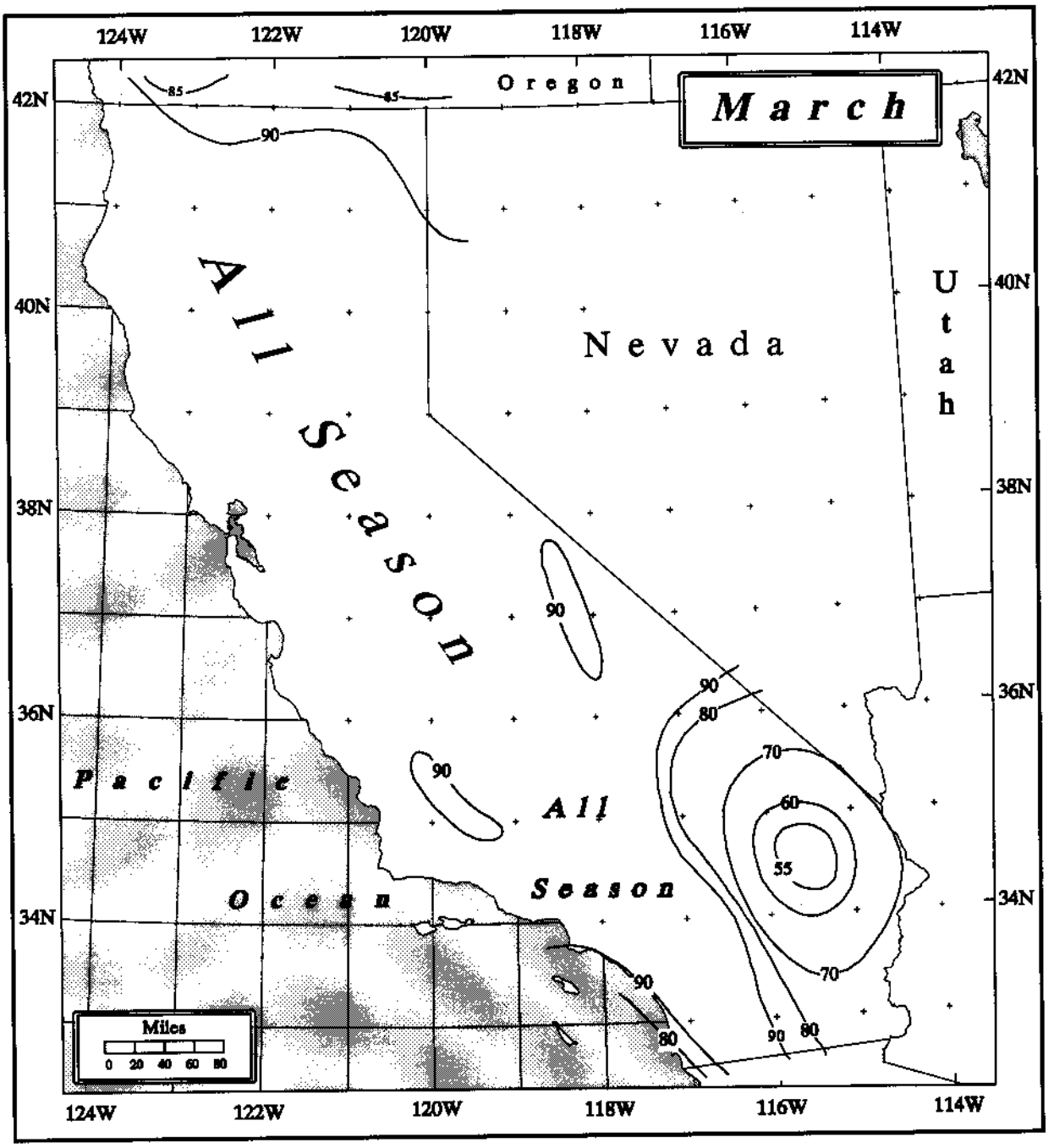

Figure 13.2. *10-mi² 24-hour general-storm PMP for March in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.3.*

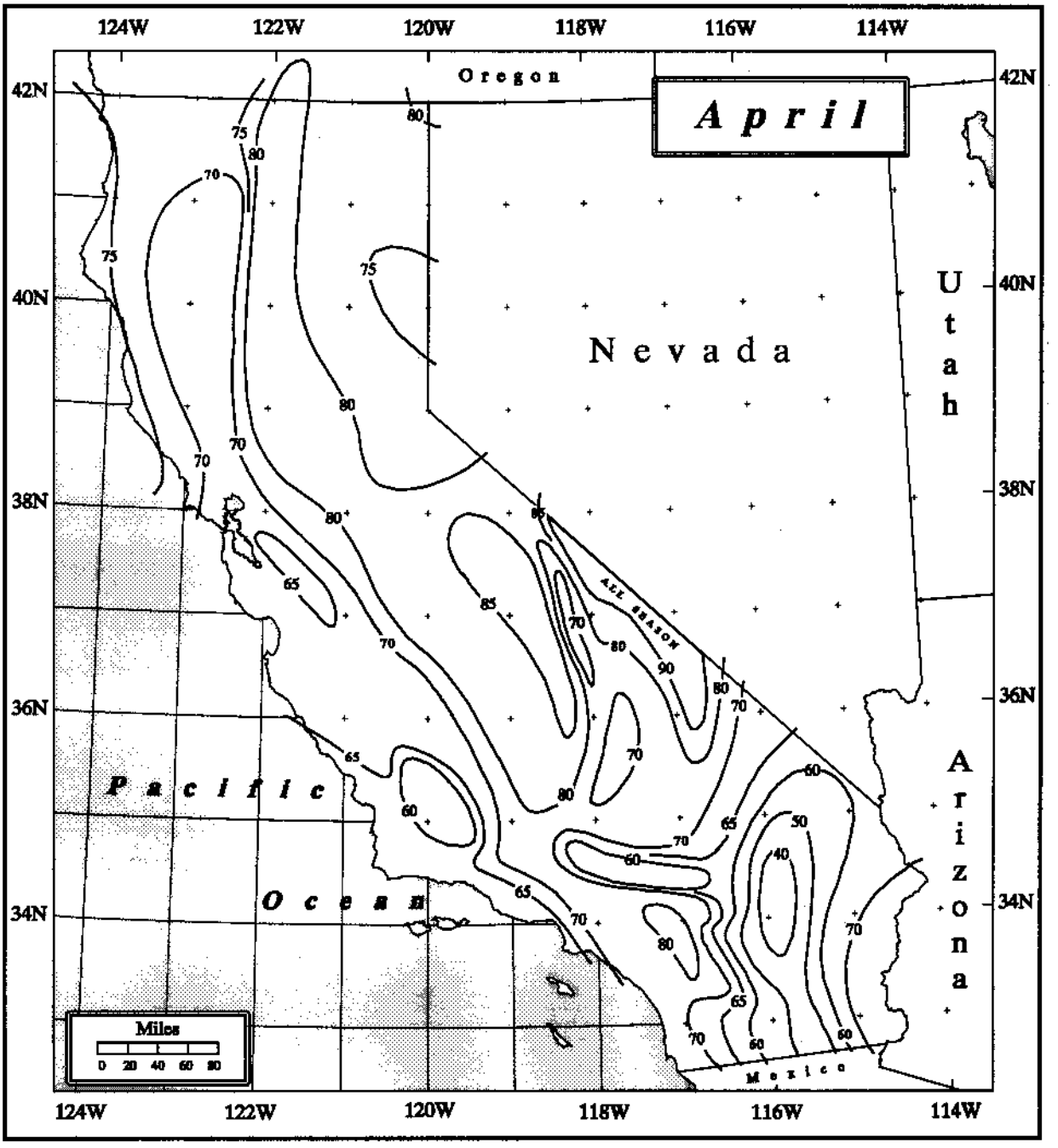

Figure 13.3. *10-mi² 24-hour general-storm PMP for April in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.4.*

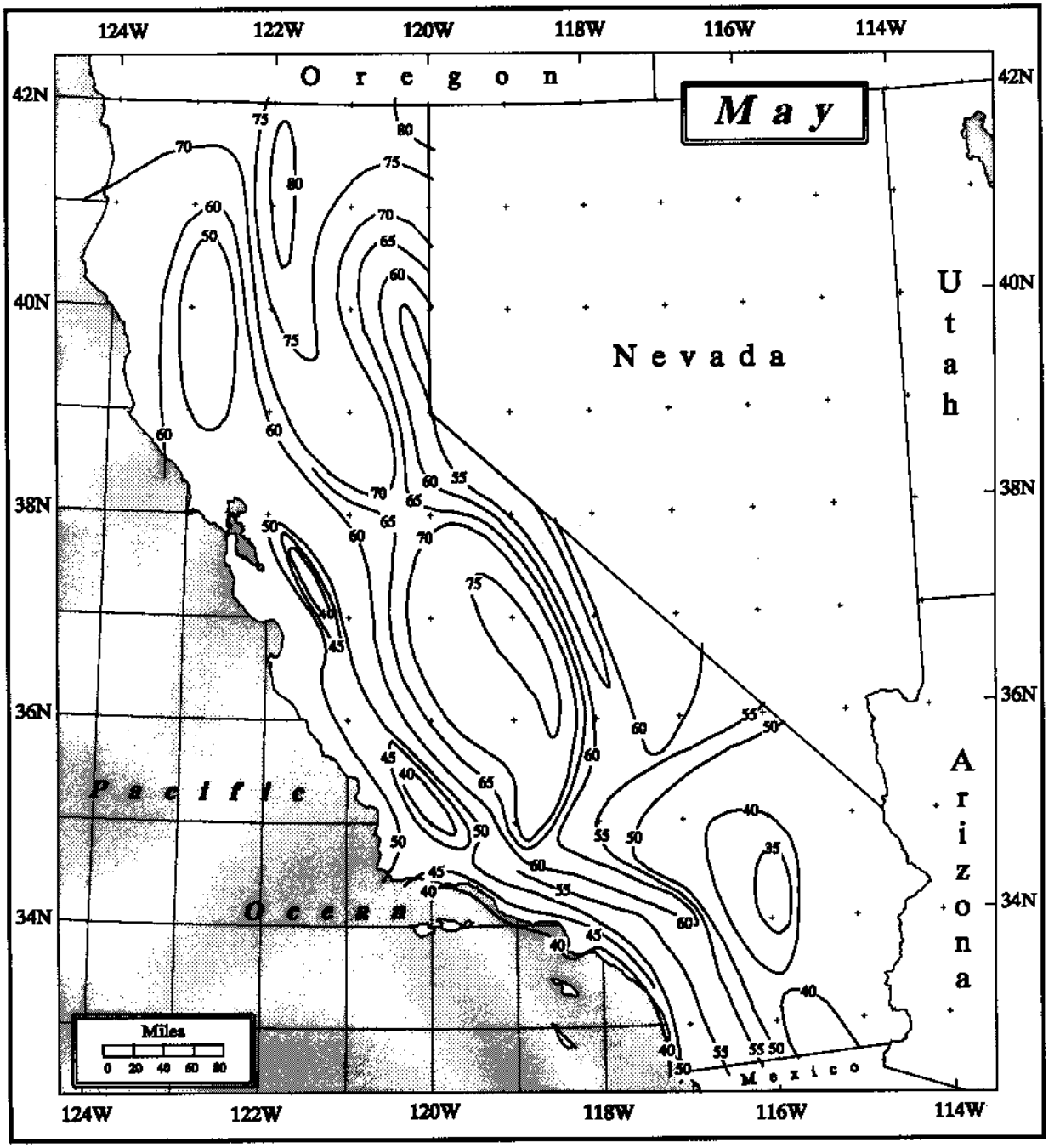

Figure 13.4. *10-mi² 24-hour general-storm PMP for May in California as a percent of all-season PMP (Plates 1 and 2). Same as Fiure 7.5.*

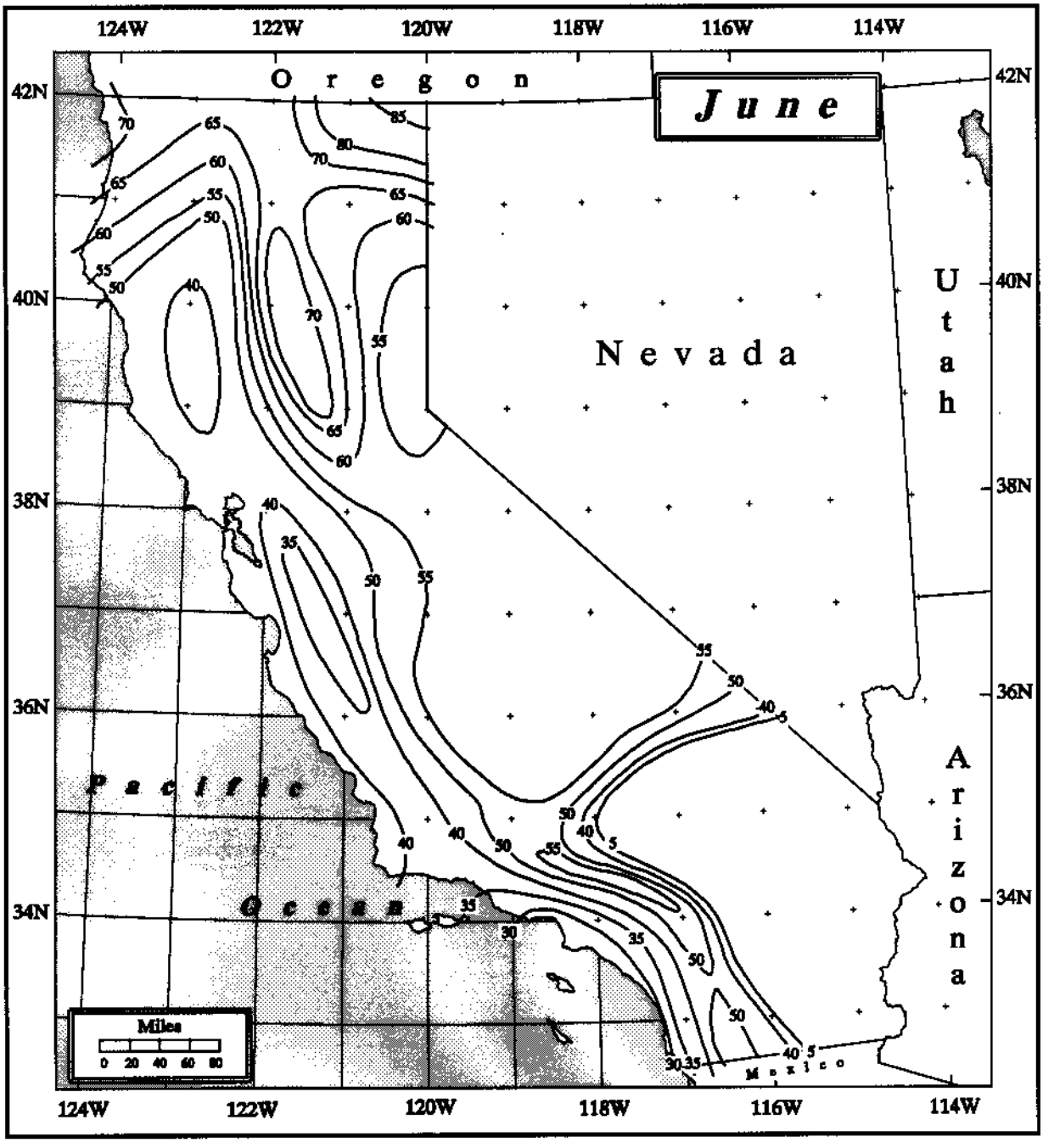

Figure 13.5. *10-mi² 24-hour general-storm PMP for June in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.6.*

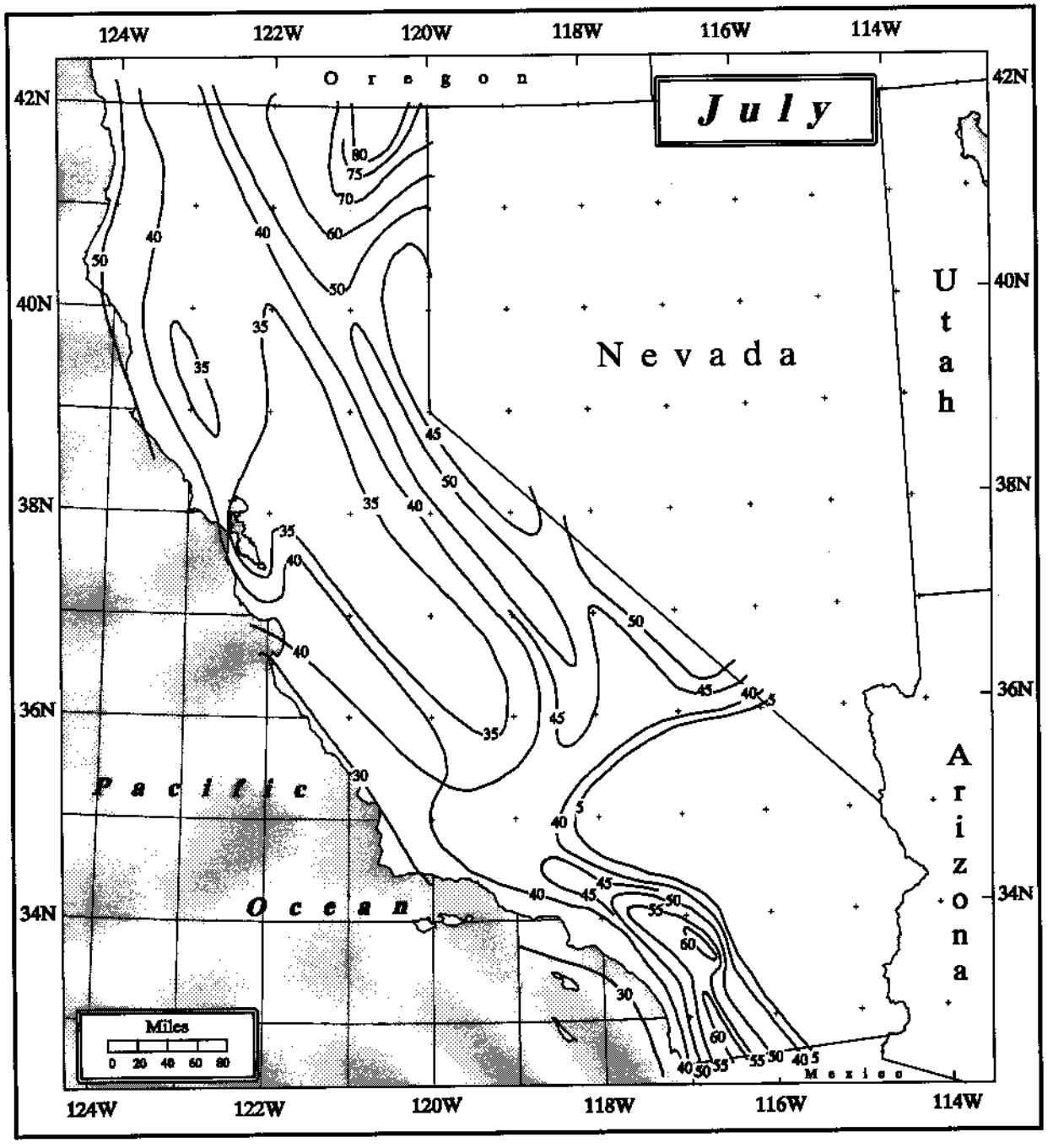

Figure 13.6. *10-mi² 24-hour general-storm PMP for July in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.7.*

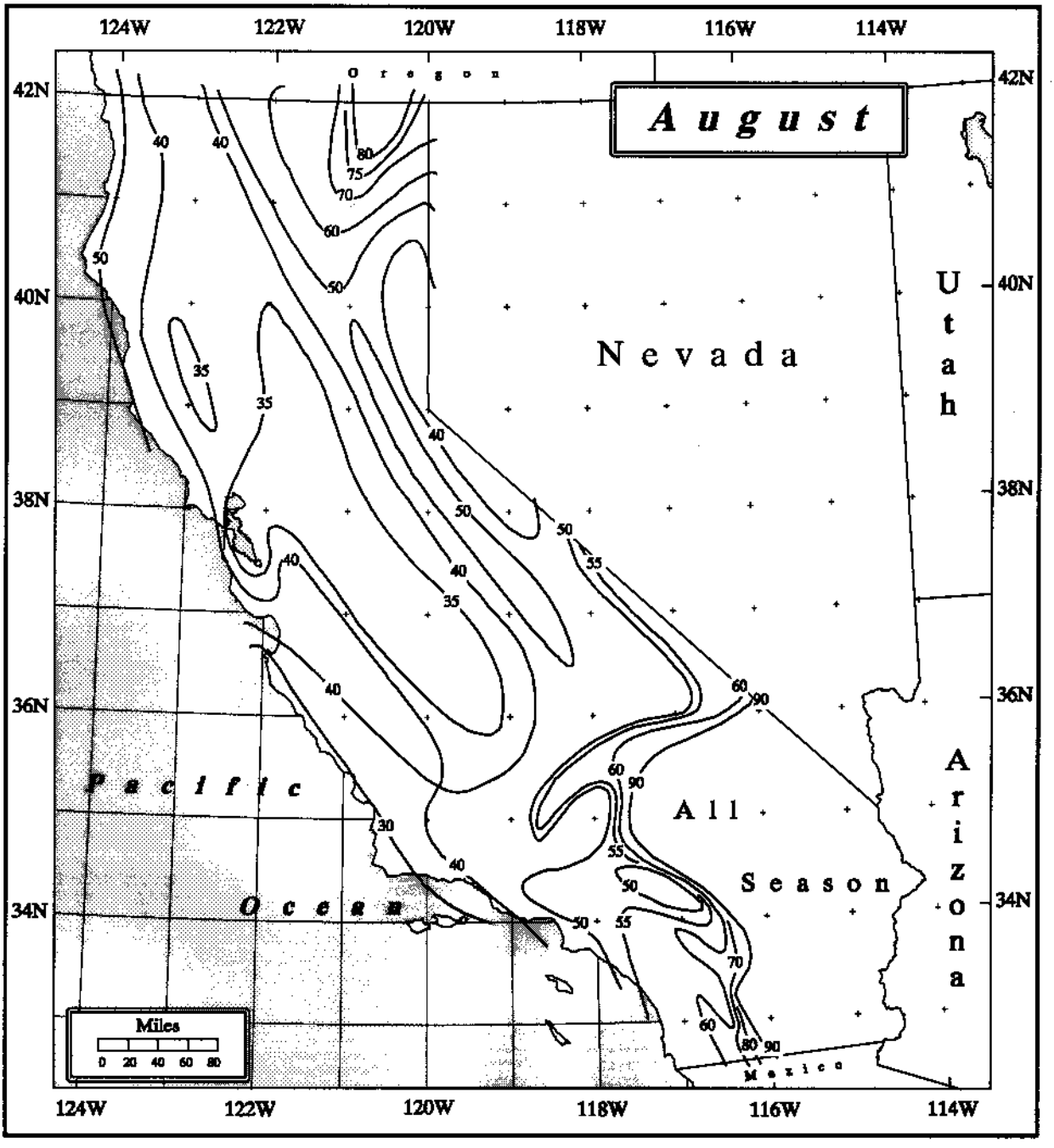

Figure 13.7. *10-mi² 24-hour general-storm PMP for August in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.8.*

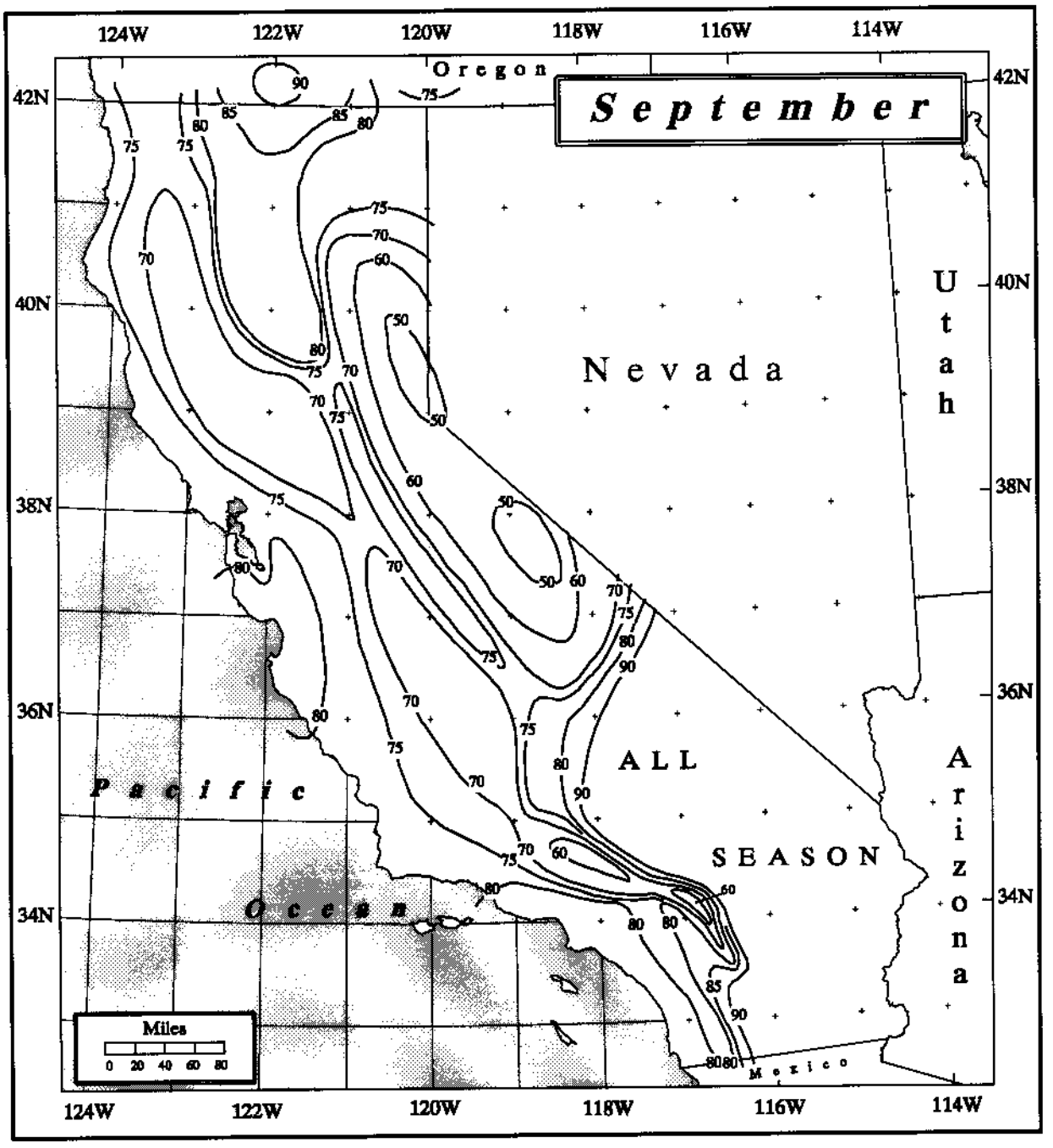

Figure 13.8. *10-mi² 24-hour general-storm PMP for September in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.9.*

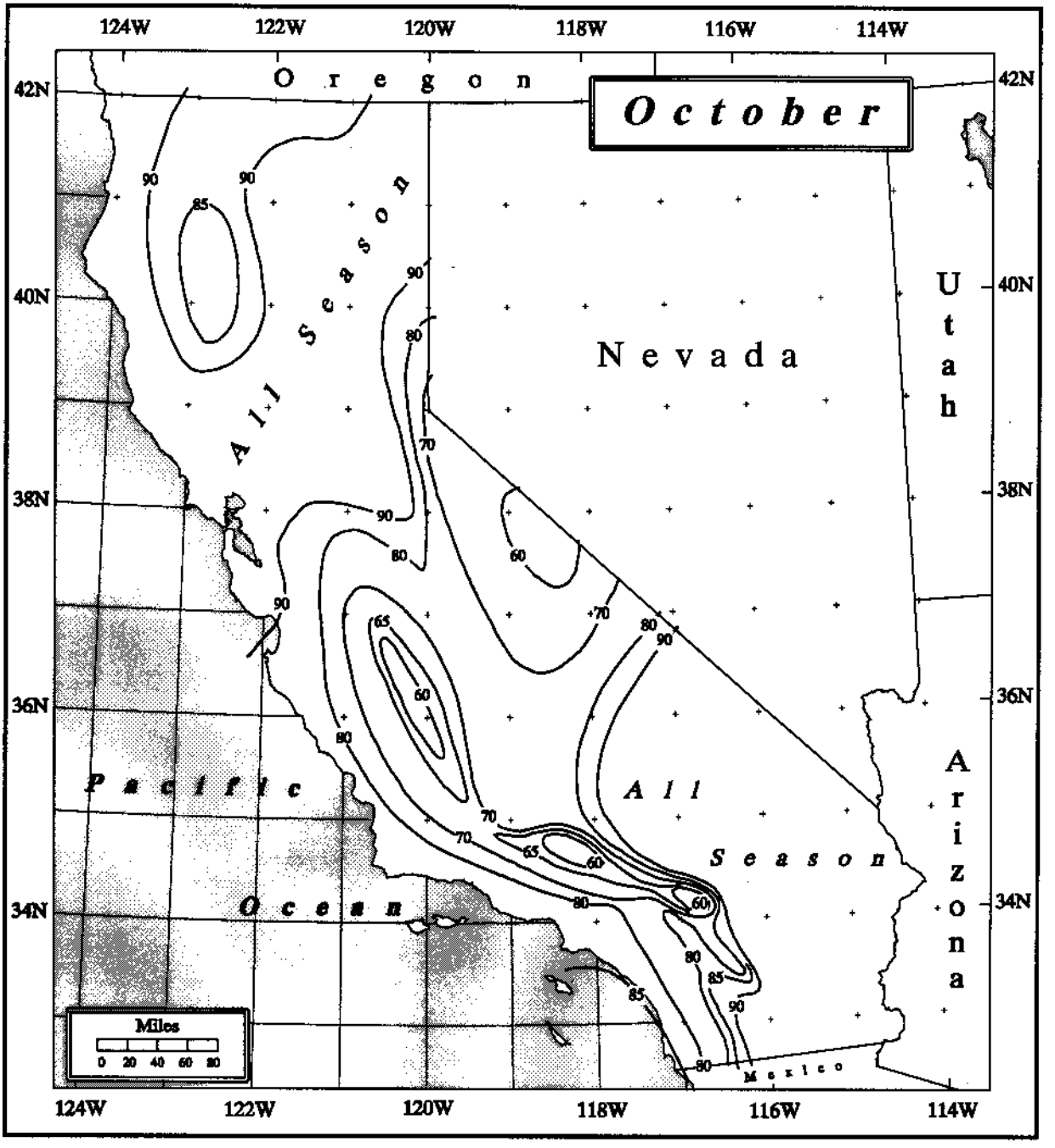

Figure 13.9. *10-mi² 24-hour general-storm PMP for October in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.10.*

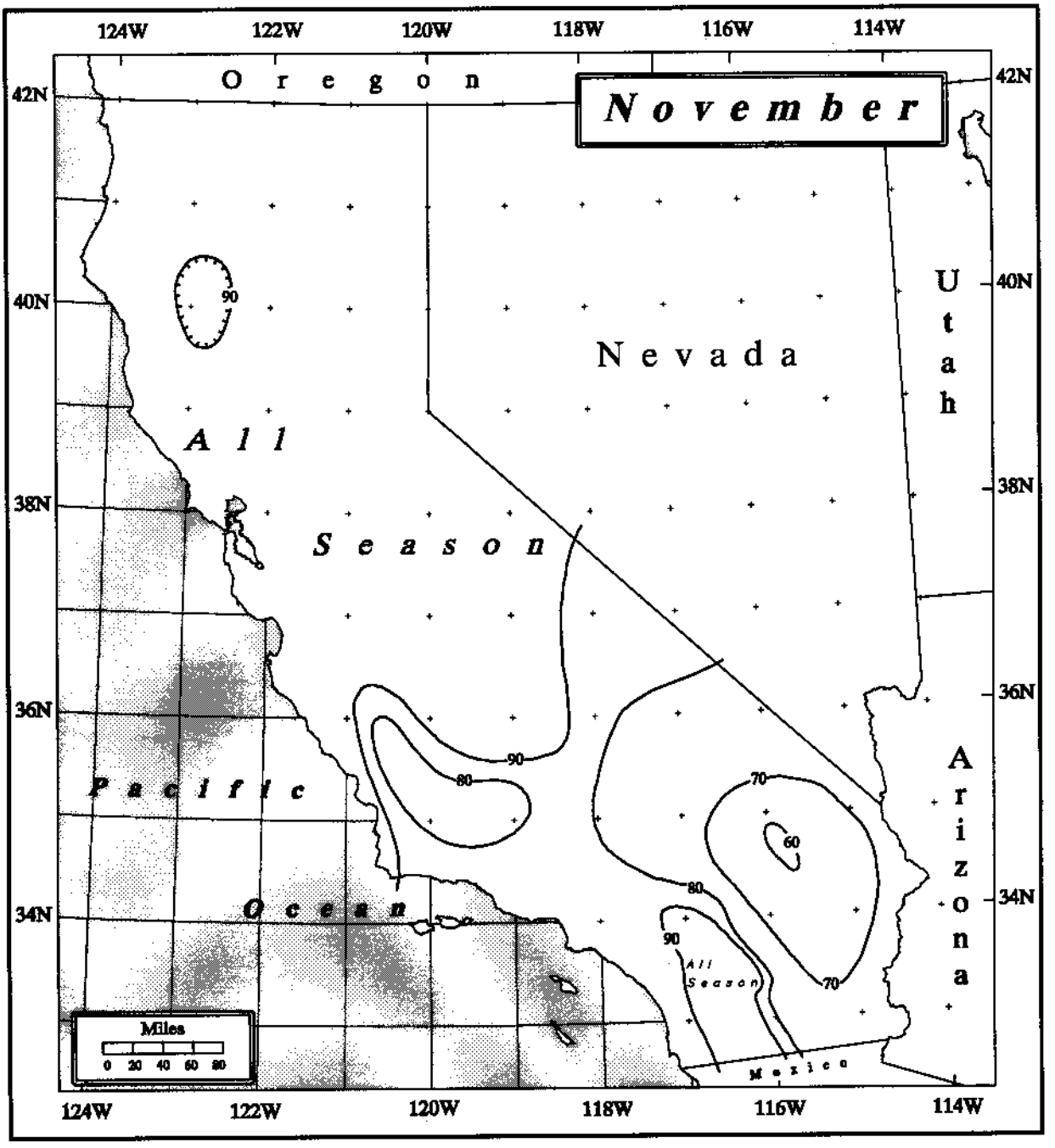

Figure 13.10. *10-mi² 24-hour general-storm PMP for November in California as a percent of all-season PMP (Plates 1 and 2). Same as Figure 7.11.*

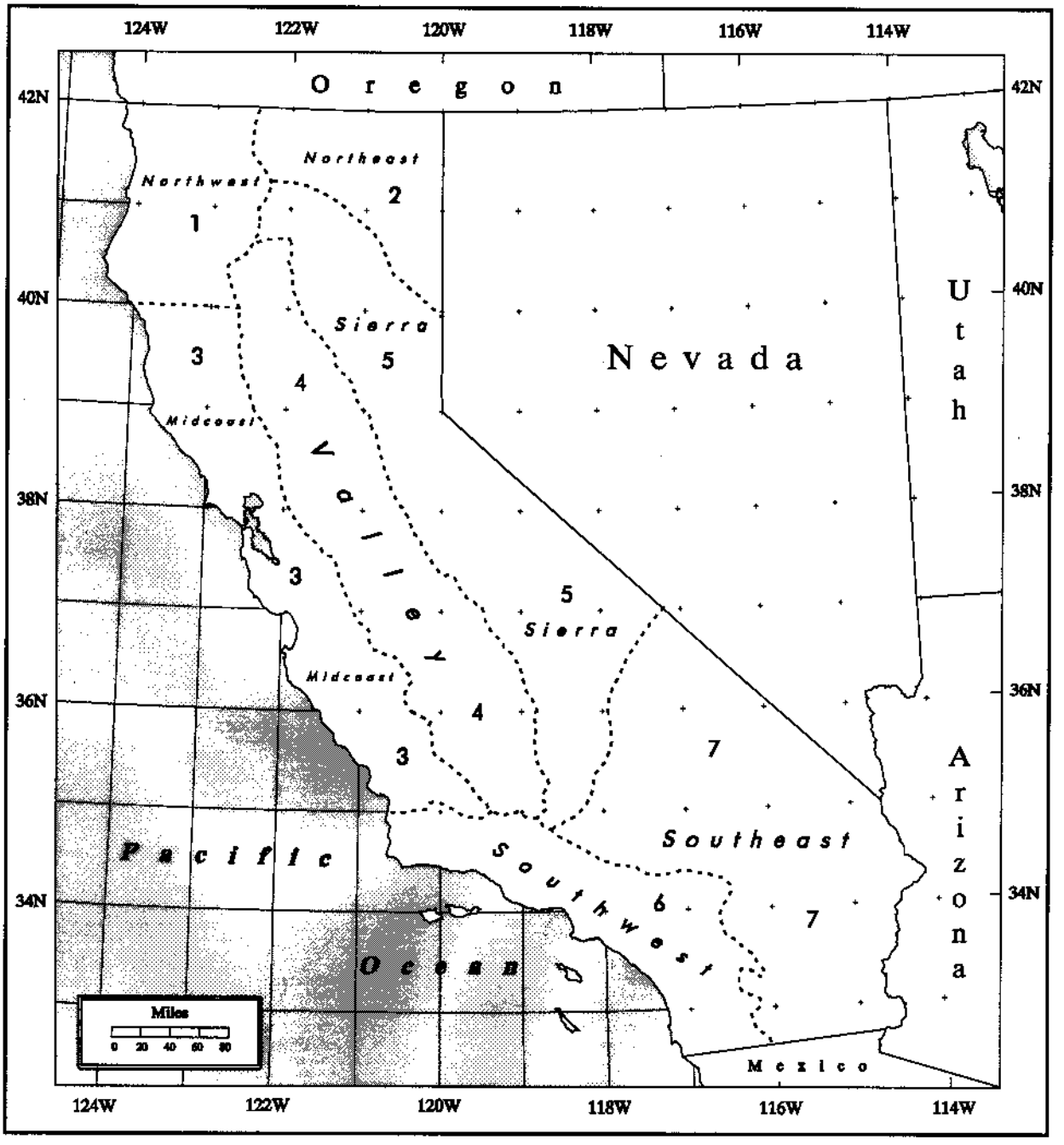

Figure 13.11. *Regional boundaries for development of depth-area-duration relations. Same as Figure 3.3.*

results; i.e., calculate results for each subregion separately and then combine the PMP values in a manner proportional to the area of each subregion. For example, for a drainage of 100 area units which encompasses three subregions each having areas of 70, 20, 10 units respectively, the resulting average value for the drainage, R, is:

$$R = ((R_1)\ 70 + (R_2)20 + (R_3)10)/100$$

where R_1, R_2, and R_3 are the average PMP values within each of the subregions within the drainage.

The following sections present the detailed steps needed to specify PMP either for all-season, i.e., an annual maximum, or for any individual month of the year. These steps are comprehensive, in the sense that they are applicable for any and every drainage in California. The procedures outlined here, along with the general-storm Index map, have been peer-reviewed. If a user finds that these steps, with their supporting maps, figures, or diagrams, do not account for some unique hydrometeorological aspect of a particular drainage, he or she should consult the Hydrometeorological Design Studies Center staff of the National Weather Service to determine the best course of action.

13.2 General Storm Procedure

Step

1. Drainage Outline

   Trace the outline of the perimeter of the drainage of concern (at 1:1,000,000 scale) onto a transparent overlay, or define the basin boundary using a Geographic Information System (GIS).

2. User Decision

   Decide whether an all-season (annual) PMP value is needed or seasonal PMP is required.

3. All-Season Index PMP Estimate

Place the drainage overlay on the appropriate all-season index map and make a uniform grid that covers the drainage. Obtain index map estimates of PMP for each grid point and determine the drainage average index PMP amount. The grid separation size should take into account the gradient of PMP across the drainage, so that reasonably representative results will be obtained. This step can also be done using a GIS or other commercial software. In areas with extreme gradients, such an analysis would be more accurate when using the digital file of Plates 1 or 2, which is available from the Hydrometeorological Design Studies Center.

4. Seasonal Index PMP Estimates

Skip to Step 5 if all-season PMP alone is required. Figures 13.1 to 13.10 are the starting point for seasonal PMP estimates. Determine the average value for each month to the nearest whole percent within the drainage and plot them on graph paper at the midpoint of each month. Draw a smooth curve through the points. In doing this a range of plus or minus 5 percent is allowed for any percentage at or below 85 percent. Select the percentage at any point in the selected month(s) from the smoothed curve. Any month with a selected percentage higher than 90 percent is treated as a month in which the all-season value of PMP applies, i.e., 100 percent applies to such a month. Multiply the all-season, average value of PMP from Step 3 by the percentage from this step.

For each month of interest determine the value of the monthly offset from the all-season envelope (90% or greater) for that month. The offset is determined by "taking the shorter path" or by counting the number of months from the nearest all-season month.

5. Depth-Duration Relations

The depth-duration subregions for California are shown on Figure 13.11. These subregions are also delineated on Plates 1 and 2. For the subregion containing the drainage of interest, read the corresponding depth-duration ratios from Table 13.1

(all-season) or Table 13.2 (seasonally adjusted) and multiply each by the 24-hour result obtained from Step 3 (all-season) or Step 4 (seasonally-adjusted). Use proportionally-weighted results if more than one subregion is subtended by a drainage boundary.

Table 13.1. *All-season PMP depth-duration ratios for 10mi² for California regions.*

	Duration					
Region	**1**	**6**	**12**	**24**	**48**	**72**
Northwest	0.10	0.40	0.73	1.00	1.49	1.77
Northeast	0.16	0.52	0.69	1.00	1.40	1.55
Midcoastal	0.13	0.45	0.74	1.00	1.45	1.70
C. Valley	0.13	0.42	0.65	1.00	1.48	1.75
Sierra	0.14	0.42	0.65	1.00	1.56	1.76
Southwest	0.14	0.48	0.76	1.00	1.41	1.59
Southeast	0.30	0.60	0.86	1.00	1.17	1.28

6. Areal Reduction Factors

Obtain the all-season reduction factors from either Table 13.3, or from Figures 13.12 to 13.17, as appropriate. For a specific month, however, use Tables 13.4 to 13.9 (interpolate to the required drainage area size) using the monthly offset for seasonal PMPs selected in step 4. Multiply the applicable reduction factors by the corresponding 10-mi² amounts from Step 5. If the drainage includes more than one subregion, again use proportionately-weighted results.

7. Incremental Estimates

If incremental values for the various durations are needed, plot the results from Step 6 on graph paper and draw a smooth curve to obtain intermediate

Table 13.2. *Seasonally adjusted 10-mi² depth-duration ratios (monthly offsets).*

Northwest

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.102	0.404	0.734	1.000	1.445	1.682
2	0.106	0.416	0.745	1.000	1.386	1.558
3	0.112	0.428	0.759	1.000	1.341	1.469
4	0.121	0.448	0.774	1.000	1.296	1.416
5	0.127	0.464	0.788	1.000	1.267	1.381

Northeast

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.163	0.525	0.693	1.000	1.358	1.473
2	0.170	0.541	0.704	1.000	1.302	1.364
3	0.179	0.556	0.718	1.000	1.260	1.287
4	0.194	0.582	0.731	1.000	1.218	1.240
5	0.203	0.603	0.745	1.000	1.190	1.209

Midcoastal

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.133	0.455	0.744	1.000	1.407	1.615
2	0.138	0.468	0.755	1.000	1.349	1.496
3	0.146	0.482	0.770	1.000	1.305	1.411
4	0.157	0.504	0.784	1.000	1.262	1.360
5	0.165	0.522	0.799	1.000	1.233	1.326

Central Valley

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.133	0.424	0.653	1.000	1.436	1.663
2	0.138	0.437	0.663	1.000	1.376	1.540
3	0.146	0.449	0.676	1.000	1.332	1.453
4	0.157	0.470	0.689	1.000	1.288	1.400
5	0.165	0.487	0.702	1.000	1.258	1.365

Table 13.2. (cont.) *Seasonally adjusted 10-mi² depth-duration ratios (monthly offsets).*

Sierra

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.143	0.424	0.653	1.000	1.513	1.672
2	0.148	0.437	0.663	1.000	1.451	1.549
3	0.157	0.449	0.676	1.000	1.404	1.461
4	0.169	0.470	0.689	1.000	1.357	1.408
5	0.178	0.487	0.702	1.000	1.326	1.373

Southwest

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.143	0.485	0.764	1.000	1.368	1.511
2	0.148	0.499	0.775	1.000	1.311	1.399
3	0.157	0.514	0.790	1.000	1.269	1.320
4	0.169	0.538	0.806	1.000	1.227	1.272
5	0.178	0.557	0.821	1.000	1.199	1.240

Southeast

Offset	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
1	0.294	0.594	0.856	1.000	1.206	1.347
2	0.283	0.577	0.843	1.000	1.258	1.455
3	0.268	0.561	0.827	1.000	1.300	1.542
4	0.248	0.536	0.811	1.000	1.345	1.600
5	0.236	0.517	0.796	1.000	1.376	1.641

Table 13.3. *All-season depth-area relations for California by region.*

Northwest / Northeast

Area (mi²)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.50	88.50	90.00	91.50	93.00	94.00
100	82.00	84.00	86.00	88.00	89.50	91.00
200	77.00	79.50	82.00	84.00	86.00	87.75
500	69.50	73.00	76.25	78.25	81.00	83.00
1000	63.00	67.50	71.00	73.50	76.50	79.00
2000	55.50	60.50	64.00	67.00	69.50	72.00
5000	42.50	49.50	52.50	56.00	59.00	62.00
10000	32.00	40.00	43.50	47.00	51.00	54.00

Midcoastal

Area (mi²)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.50	88.75	90.00	91.00	92.00	93.00
100	81.75	83.75	85.50	87.00	88.50	90.00
200	75.75	78.25	80.50	82.50	84.50	86.25
500	67.50	71.00	73.50	76.00	78.50	80.50
1000	60.75	65.50	68.00	70.50	73.00	75.50
2000	53.00	58.50	61.50	64.00	67.00	70.00
5000	38.00	44.50	48.50	52.00	55.00	59.00

Central Valley

Area (mi²)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	100.00	100.00	100.00	100.00	100.00	100.00
50	84.50	87.25	89.50	91.50	92.75	94.00
100	77.25	81.00	84.00	86.50	88.50	90.50
200	70.00	74.50	78.00	81.00	83.00	85.00
500	59.75	64.75	68.75	72.00	74.50	77.00
1000	51.00	56.50	61.00	64.50	67.00	69.50
2000	41.00	47.50	52.00	55.50	58.50	61.50
5000	27.00	33.75	38.50	42.00	45.25	48.50
10000	14.00	21.00	26.00	30.00	33.00	36.50
10000	25.00	34.00	38.00	42.00	45.00	49.00

Table 13.3 (cont.) *All-season depth-area relations for California by region.*

Sierra

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	100.00	100.00	100.00	100.00	100.00	100.00
50	88.00	89.00	90.00	91.00	92.50	94.00
100	82.50	84.00	85.50	87.00	89.25	91.25
200	76.75	78.75	80.75	82.75	85.50	88.25
500	69.25	71.75	74.25	77.00	80.50	83.50
1000	63.25	66.25	69.25	72.25	76.25	79.75
2000	57.00	60.00	63.50	67.00	71.25	75.25
5000	47.50	51.00	55.00	59.00	63.50	68.00
10000	40.00	44.00	48.00	52.50	57.50	62.00

Southwest

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.75	88.50	89.50	90.50	91.75	92.75
100	81.75	83.25	84.75	86.25	87.75	89.25
200	75.75	78.00	79.75	81.50	83.75	85.75
500	67.50	70.50	72.50	75.00	77.50	80.00
1000	60.00	63.50	66.00	69.00	71.75	74.75
2000	51.00	56.00	59.00	62.00	65.00	68.00
5000	35.00	41.00	46.00	50.00	52.50	56.00
10000	22.00	30.00	34.00	38.00	42.00	46.00

Southeast

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	100.00	100.00	100.00	100.00	100.00	100.00
50	89.00	90.50	91.75	93.00	94.50	96.00
100	83.50	85.25	87.25	89.00	90.75	92.50
200	76.50	79.75	82.00	84.00	86.00	88.00
500	66.00	70.75	74.00	76.50	78.75	81.00
1000	56.50	63.25	67.00	70.00	72.50	75.00
2000	46.00	54.75	59.00	62.00	64.75	67.50
5000	31.25	41.50	47.00	50.00	52.50	55.50
10000	19.00	30.00	36.00	39.50	42.50	45.00

Table 13.4. *Seasonally adjusted areal reduction factors for the Northeast and Northwest regions.*

Offset 1 Month						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.913	0.930	0.948	0.960	0.967	0.975
100	0.861	0.883	0.905	0.928	0.945	0.960
200	0.785	0.818	0.847	0.871	0.900	0.919
500	0.677	0.725	0.769	0.798	0.835	0.859
1000	0.582	0.644	0.690	0.730	0.762	0.790
2000	0.480	0.559	0.608	0.650	0.680	0.709
5000	0.340	0.436	0.478	0.524	0.561	0.595
10000	0.240	0.338	0.372	0.418	0.467	0.502
Offset 2 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.894	0.921	0.939	0.952	0.959	0.965
100	0.831	0.868	0.892	0.916	0.929	0.941
200	0.753	0.802	0.834	0.858	0.880	0.892
500	0.641	0.702	0.746	0.778	0.806	0.825
1000	0.544	0.617	0.658	0.697	0.728	0.751
2000	0.447	0.528	0.570	0.610	0.639	0.666
5000	0.313	0.401	0.436	0.484	0.519	0.552
10000	0.218	0.302	0.335	0.381	0.428	0.459
Offset 3 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.883	0.916	0.933	0.944	0.950	0.955
100	0.809	0.859	0.882	0.904	0.916	0.926
200	0.729	0.789	0.821	0.844	0.867	0.878
500	0.619	0.687	0.726	0.757	0.785	0.803
1000	0.522	0.596	0.636	0.671	0.697	0.719
2000	0.425	0.500	0.541	0.576	0.605	0.634
5000	0.294	0.374	0.412	0.451	0.481	0.512
10000	0.205	0.284	0.320	0.355	0.393	0.424

Table 13.4. (cont.) *Seasonally adjusted areal reduction factors for the Northeast and Northwest regions.*

Offset 4 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.865	0.902	0.926	0.940	0.946	0.952
100	0.787	0.837	0.869	0.890	0.901	0.913
200	0.696	0.760	0.800	0.821	0.842	0.853
500	0.576	0.649	0.695	0.721	0.747	0.765
1000	0.474	0.555	0.601	0.633	0.658	0.679
2000	0.375	0.464	0.502	0.536	0.563	0.590
5000	0.244	0.337	0.375	0.412	0.435	0.459
10000	0.162	0.248	0.283	0.317	0.354	0.383
Offset 5 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.851	0.893	0.917	0.931	0.946	0.955
100	0.770	0.823	0.851	0.874	0.886	0.898
200	0.672	0.743	0.778	0.801	0.822	0.833
500	0.551	0.627	0.667	0.697	0.722	0.740
1000	0.448	0.538	0.572	0.607	0.635	0.660
2000	0.347	0.445	0.480	0.516	0.546	0.572
5000	0.216	0.322	0.352	0.392	0.425	0.453
10000	0.141	0.228	0.261	0.298	0.339	0.367

Table 13.5. *Seasonally adjusted areal reduction factors for the Midcoastal region.*

Offset 1 Month

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.903	0.915	0.928	0.943	0.957	0.975
100	0.846	0.868	0.886	0.908	0.930	0.949
200	0.775	0.804	0.832	0.856	0.885	0.909
500	0.663	0.710	0.750	0.778	0.815	0.838
1000	0.564	0.630	0.671	0.706	0.738	0.770
2000	0.458	0.536	0.584	0.621	0.655	0.690
5000	0.308	0.392	0.441	0.486	0.523	0.566
10000	0.188	0.287	0.325	0.374	0.412	0.456

Offset 2 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.885	0.906	0.919	0.935	0.949	0.965
100	0.817	0.853	0.872	0.896	0.914	0.931
200	0.743	0.787	0.820	0.843	0.866	0.882
500	0.627	0.688	0.727	0.758	0.786	0.805
1000	0.527	0.603	0.639	0.673	0.704	0.732
2000	0.427	0.506	0.547	0.582	0.616	0.648
5000	0.283	0.360	0.403	0.450	0.484	0.525
10000	0.170	0.257	0.293	0.340	0.378	0.417

Offset 3 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.874	0.902	0.913	0.927	0.940	0.955
100	0.795	0.844	0.862	0.885	0.901	0.917
200	0.719	0.775	0.807	0.830	0.852	0.869
500	0.606	0.673	0.708	0.739	0.766	0.784
1000	0.505	0.583	0.619	0.648	0.674	0.701
2000	0.405	0.480	0.520	0.550	0.583	0.616
5000	0.266	0.336	0.381	0.419	0.448	0.487
10000	0.160	0.241	0.279	0.317	0.347	0.385

Table 13.5. (cont.) *Seasonally adjusted areal reduction factors for the Midcoastal region.*

Offset 4 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.855	0.888	0.907	0.923	0.936	0.952
100	0.774	0.823	0.850	0.871	0.887	0.903
200	0.688	0.746	0.786	0.807	0.827	0.843
500	0.564	0.636	0.677	0.703	0.729	0.747
1000	0.459	0.543	0.584	0.612	0.637	0.662
2000	0.358	0.445	0.483	0.512	0.543	0.574
5000	0.220	0.303	0.347	0.382	0.406	0.437
10000	0.126	0.211	0.247	0.284	0.313	0.348

Offset 5 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	0.000
50	0.842	0.879	0.897	0.915	0.936	0.000
100	0.757	0.809	0.832	0.855	0.872	0.000
200	0.664	0.730	0.765	0.787	0.808	48.000
500	0.539	0.614	0.650	0.679	0.705	1.016
1000	0.434	0.526	0.556	0.587	0.615	0.919
2000	0.331	0.427	0.461	0.493	0.526	0.875
5000	0.196	0.289	0.325	0.364	0.396	0.834
10000	0.110	0.194	0.228	0.267	0.299	0.749

Table 13.6. *Seasonally adjusted areal reduction factors for the Central Valley region.*

Offset 1 Month

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.828	0.886	0.918	0.940	0.952	0.970
100	0.752	0.823	0.866	0.893	0.915	0.934
200	0.663	0.750	0.798	0.832	0.860	0.889
500	0.536	0.638	0.701	0.739	0.775	0.803
1000	0.437	0.541	0.608	0.652	0.683	0.715
2000	0.333	0.440	0.504	0.548	0.582	0.616
5000	0.207	0.295	0.350	0.393	0.432	0.466
10000	0.113	0.182	0.222	0.267	0.302	0.339

Offset 2 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.812	0.877	0.909	0.932	0.944	0.960
100	0.726	0.809	0.853	0.882	0.899	0.916
200	0.636	0.734	0.786	0.819	0.841	0.862
500	0.507	0.618	0.679	0.720	0.748	0.771
1000	0.408	0.518	0.580	0.622	0.652	0.679
2000	0.310	0.415	0.472	0.514	0.547	0.578
5000	0.190	0.271	0.320	0.363	0.400	0.432
10000	0.102	0.162	0.200	0.243	0.277	0.310

Offset 3 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.802	0.872	0.903	0.924	0.935	0.951
100	0.707	0.801	0.843	0.870	0.886	0.902
200	0.615	0.723	0.774	0.806	0.828	0.849
500	0.490	0.605	0.661	0.701	0.729	0.751
1000	0.391	0.500	0.561	0.599	0.624	0.651
2000	0.295	0.394	0.448	0.486	0.518	0.550
5000	0.179	0.253	0.302	0.338	0.371	0.400
10000	0.096	0.153	0.191	0.227	0.254	0.287

Table 13.6. (cont.) *Seasonally adjusted areal reduction factors for the Central Valley region.*

Offset 4 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.785	0.859	0.897	0.920	0.931	0.947
100	0.688	0.780	0.831	0.857	0.873	0.889
200	0.588	0.696	0.753	0.784	0.804	0.825
500	0.456	0.572	0.633	0.668	0.694	0.716
1000	0.355	0.466	0.529	0.565	0.590	0.615
2000	0.260	0.365	0.416	0.452	0.482	0.513
5000	0.148	0.228	0.275	0.309	0.336	0.359
10000	0.076	0.133	0.169	0.203	0.229	0.259
Offset 5 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.772	0.850	0.888	0.912	0.931	0.951
100	0.673	0.768	0.813	0.841	0.858	0.874
200	0.568	0.681	0.733	0.764	0.785	0.805
500	0.436	0.552	0.608	0.645	0.670	0.692
1000	0.336	0.451	0.504	0.542	0.569	0.597
2000	0.241	0.350	0.398	0.435	0.467	0.497
5000	0.131	0.218	0.258	0.294	0.328	0.354
10000	0.066	0.123	0.156	0.191	0.219	0.248

Table 13.7. *Seasonally adjusted areal reduction factors for the Sierra region.*

Offset 1 Month

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.908	0.920	0.933	0.950	0.962	0.985
100	0.851	0.868	0.886	0.908	0.930	0.960
200	0.775	0.799	0.822	0.851	0.880	0.919
500	0.667	0.706	0.745	0.778	0.820	0.859
1000	0.582	0.630	0.676	0.715	0.762	0.810
2000	0.493	0.550	0.603	0.650	0.699	0.749
5000	0.385	0.449	0.501	0.552	0.608	0.653
10000	0.300	0.372	0.410	0.472	0.531	0.577

Offset 2 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.889	0.911	0.924	0.942	0.954	0.975
100	0.821	0.853	0.872	0.896	0.914	0.941
200	0.743	0.782	0.810	0.839	0.861	0.892
500	0.632	0.684	0.722	0.758	0.791	0.825
1000	0.544	0.603	0.644	0.683	0.728	0.770
2000	0.459	0.519	0.565	0.610	0.658	0.703
5000	0.354	0.413	0.457	0.510	0.563	0.605
10000	0.272	0.332	0.370	0.429	0.487	0.527

Offset 3 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.878	0.907	0.918	0.934	0.945	0.965
100	0.800	0.844	0.862	0.885	0.901	0.926
200	0.719	0.770	0.797	0.825	0.847	0.878
500	0.611	0.669	0.703	0.739	0.771	0.803
1000	0.522	0.583	0.623	0.657	0.697	0.737
2000	0.436	0.492	0.537	0.576	0.622	0.669
5000	0.333	0.385	0.432	0.475	0.522	0.561
10000	0.256	0.312	0.353	0.400	0.447	0.487

Table 13.7. (cont.) *Seasonally adjusted areal reduction factors for the Sierra region.*

Offset 4 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.860	0.893	0.912	0.930	0.941	0.961
100	0.778	0.823	0.850	0.871	0.887	0.913
200	0.688	0.742	0.777	0.802	0.823	0.853
500	0.568	0.632	0.673	0.703	0.734	0.765
1000	0.474	0.543	0.588	0.621	0.658	0.697
2000	0.385	0.456	0.498	0.536	0.579	0.623
5000	0.276	0.347	0.393	0.434	0.472	0.503
10000	0.202	0.273	0.312	0.358	0.403	0.440

Offset 5 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.846	0.883	0.902	0.922	0.941	0.965
100	0.761	0.809	0.832	0.855	0.872	0.898
200	0.664	0.725	0.756	0.783	0.803	0.833
500	0.543	0.610	0.646	0.679	0.709	0.740
1000	0.448	0.526	0.560	0.595	0.635	0.676
2000	0.356	0.438	0.476	0.516	0.561	0.604
5000	0.245	0.332	0.369	0.413	0.461	0.496
10000	0.176	0.251	0.288	0.337	0.386	0.422

Table 13.8. *Seasonally adjusted areal reduction factors for the Southwest region.*

Offset 1 Month

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.893	0.915	0.928	0.940	0.952	0.965
100	0.837	0.863	0.881	0.898	0.920	0.939
200	0.770	0.799	0.818	0.842	0.870	0.899
500	0.658	0.696	0.730	0.758	0.795	0.828
1000	0.555	0.611	0.647	0.686	0.723	0.760
2000	0.441	0.513	0.561	0.601	0.636	0.670
5000	0.284	0.361	0.419	0.468	0.499	0.538
10000	0.165	0.254	0.291	0.338	0.384	0.428

Offset 2 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.875	0.906	0.919	0.932	0.944	0.955
100	0.807	0.848	0.867	0.887	0.904	0.921
200	0.739	0.782	0.805	0.829	0.851	0.872
500	0.623	0.674	0.708	0.739	0.767	0.795
1000	0.519	0.585	0.616	0.655	0.690	0.722
2000	0.411	0.484	0.525	0.564	0.598	0.629
5000	0.261	0.332	0.382	0.433	0.462	0.498
10000	0.150	0.227	0.262	0.308	0.353	0.391

Offset 3 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.864	0.902	0.913	0.924	0.935	0.946
100	0.786	0.840	0.858	0.875	0.891	0.907
200	0.715	0.770	0.793	0.815	0.838	0.859
500	0.602	0.660	0.689	0.720	0.747	0.775
1000	0.497	0.566	0.596	0.630	0.661	0.692
2000	0.390	0.459	0.499	0.533	0.566	0.598
5000	0.245	0.310	0.361	0.403	0.428	0.462
10000	0.141	0.213	0.250	0.287	0.323	0.361

Table 13.8. (cont.) *Seasonally adjusted areal reduction factors for the Southwest region.*

Offset 4 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.846	0.888	0.907	0.920	0.931	0.942
100	0.765	0.818	0.845	0.861	0.877	0.894
200	0.683	0.742	0.772	0.793	0.813	0.834
500	0.560	0.624	0.659	0.685	0.712	0.738
1000	0.451	0.527	0.563	0.595	0.624	0.654
2000	0.344	0.426	0.463	0.496	0.527	0.558
5000	0.203	0.279	0.329	0.368	0.387	0.414
10000	0.111	0.186	0.221	0.257	0.292	0.327
Offset 5 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.833	0.879	0.897	0.912	0.931	0.946
100	0.748	0.805	0.827	0.846	0.863	0.879
200	0.660	0.725	0.751	0.774	0.794	0.814
500	0.536	0.602	0.633	0.662	0.688	0.713
1000	0.427	0.510	0.536	0.571	0.602	0.635
2000	0.319	0.409	0.443	0.477	0.510	0.541
5000	0.180	0.267	0.308	0.350	0.378	0.409
10000	0.097	0.171	0.204	0.241	0.279	0.313

Table 13.9. *Seasonally adjusted areal reduction factors for the Southeast region.*

Offset 1 Month

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.902	0.935	0.945	0.952	0.964	0.970
100	0.838	0.877	0.894	0.912	0.920	0.929
200	0.779	0.832	0.848	0.874	0.880	0.891
500	0.713	0.760	0.776	0.807	0.820	0.837
1000	0.643	0.702	0.725	0.745	0.763	0.780
2000	0.561	0.622	0.647	0.655	0.675	0.690
5000	0.389	0.477	0.522	0.535	0.553	0.573
10000	0.253	0.355	0.427	0.444	0.464	0.484

Offset 2 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.921	0.944	0.954	0.960	0.972	0.980
100	0.869	0.892	0.908	0.924	0.936	0.947
200	0.813	0.849	0.861	0.887	0.900	0.918
500	0.753	0.785	0.800	0.828	0.850	0.871
1000	0.688	0.733	0.761	0.781	0.799	0.821
2000	0.602	0.659	0.691	0.698	0.717	0.735
5000	0.423	0.519	0.572	0.578	0.597	0.618
10000	0.279	0.397	0.474	0.488	0.506	0.529

Offset 3 Months

Area (mi^2)	1 hr	6 hr	12 hr	24 hr	48 hr	72 hr
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.932	0.949	0.960	0.968	0.982	0.990
100	0.892	0.902	0.918	0.936	0.950	0.962
200	0.840	0.862	0.874	0.902	0.914	0.933
500	0.779	0.802	0.822	0.850	0.872	0.894
1000	0.718	0.759	0.787	0.811	0.834	0.857
2000	0.634	0.695	0.728	0.738	0.759	0.773
5000	0.450	0.556	0.605	0.621	0.644	0.667
10000	0.297	0.423	0.497	0.523	0.552	0.573